



CTD90 – Probe

Manual and operating instructions



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1 General description

The CTD90 is a small and handy microprocessor controlled multiparameter probe for precise online measurements of chemical, physical and optical parameters. The housing of the probe is pressure resistant up to 500 m (2000 m optional) depth; the maximum allowable operation depth depends on the sensors line-up. Due to its handiness and its low weight it is particularly suitable for portable employment without the use of a winch.

The small housing diameter of 90 mm only allows a maximum of 9 sensors that can be accommodated to the sensor base. Additional sensors or instruments can be attached externally to the probe via underwater connectors (maximum of 5 external instruments). The CTD90 is able to release multi water samplers and plankton multi nets and to recognize the status of these units (number of bottles closed or number of net changes).

The CTD90 runs on standard single conductor cables with constant current, the measurement readings are transmitted as FSK-signals modulated on the DC supply. This method of operation requires a specific probe interface, which generates the constant current and converts the FSK-signals into PC-compatible RS232-signals. This kind of data transmission can bridge some kilometres of cable without data errors or disturbances.

For shorter distances (several hundred metres) a multicore cable can be used. The probe is then supplied with constant voltage (battery or DC power supply). The PC received data directly from the probe as RS-232C signal. A specific interface is not required by this mode of operation.

The CTD90 is equipped with a 16-channel data acquisition system with 20-bit resolution. A high long-time stability and automatic self-calibration of the analogue digital converter guarantees stable and precise CTD measurements for many years.

A very important feature is that the CTD90 is nearly free of corrosion, since all mechanical parts and sensors are made of titanium except screws and pressure transducer. This fact guarantees long lifetime and proper function of all mechanical components even under worst ambient conditions.

2 Mechanical characteristics

All parts of the probe, which are exposed to seawater, are made of corrosion-proof metals or plastics. Essentially the probe consists of the following mechanical structural components:

Housing: - Pressure tube

- Probe base

- Probe lid

Sensor protection cage

Sensors

The sensors are described in a separate chapter. The underwater housing consists of a cylindrical tube closed on both ends with caps and sealed with two O-rings each.

2.1 Pressure tube

The pressure tube is made of a solid-drawn seamless titanium tube with an external diameter of 89 mm, a wall thickness of 3 mm and is able to withstand 500 m water depth. There are 4 drill holes in 90° graduation situated 11 mm away from each tube-end. These holes are used for fixing of base and lid to the pressure tube with 4 stainless steel screws M3*6mm. The inside of the tube ends are slightly bored so that both of the inner o-rings fit neatly.

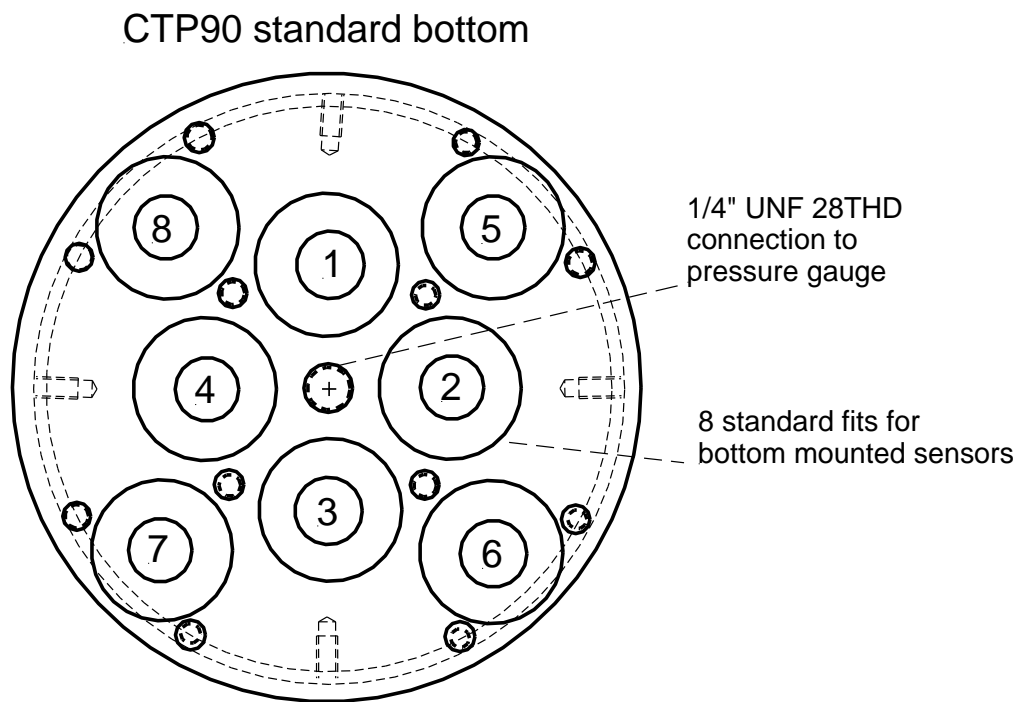
2.2 Probe base

The probe base is made of solid titanium and is used for the attachment of nearly all sensors. Fig.1 shows the principle arrangement of the sensor positions.

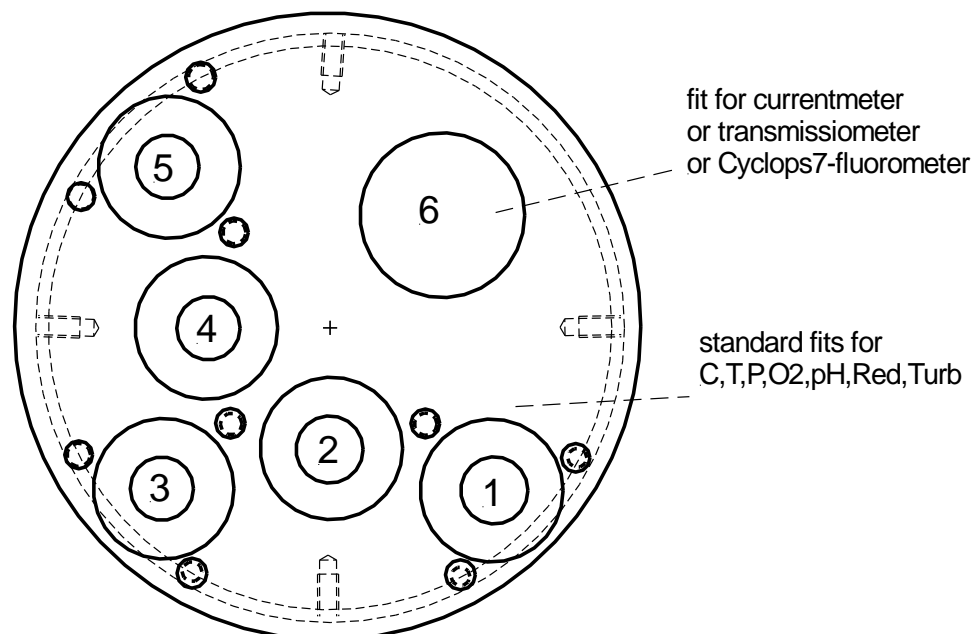
Standard probe

The base has room for 9 sensors: the pressure sensor is always mounted in the centre position. For the remaining sensors there are 8 fits. The sensors are inserted into these fits; the M4-tapped holes situated between the fits are for fastening the sensor flange with M4-screws. All sensors (except the pressure sensor) have identical flanges. The pressure transducer is inserted to the base inside and held by a M18*1 nut against the pressure from outside. A ¼"UNF28THD tapped hole is for connecting the base to a pressure gauge so that the pressure sensor can be calibrated when installed.

Figure 1



CTP90 bottom with
integrated currentmeter, transmissiometer or Cyclops7



CTD90 probe with integrated current meter or transmissiometer

The flange of the current meter and transmissiometer has a diameter of 40 mm and requires more space on the bottom than the standard sensors (approximately 25 mm diameter). It is not possible to mount the pressure transducer in the centre position. Hence the pressure sensor gets its own housing and is plugged in one of the five remaining standard fits. The calibration connection thread for the pressure gauge has the ISO size M8 * 1,25 mm.

The printed circuit boards (PCB) are screwed on a bedplate made of 1,5 mm aluminium sheet which is mounted on the inside of bottom cap.

Lid and pressure tube are sealed by two O-rings 76 * 2,5mm and are bolted onto the side with 4 screws M3*4.

2.3 Probe lid

The lid has the same dimensions as the base and is also made of titanium. Fastening and sealing are identical to that of the base. Screwed into the lid is a supporting bolt with a loop for hanging it onto a shackle. The standard version includes one underwater bulkhead connector in the lid. In all a maximum of 6 plugs (SUBCONN MICRO series) can be accommodated next to the suspension bolt so that 5 additional instruments or sensors can be connected to the CTD90.

A circular board is situated on the inside of the lid. It contains the DC-DC-converter, the cable-driver and the FSK modulator. The connection to the sensor electronics is established by a separable cable-connection on the lid.

2.4 Sensor protection cage

A sensor protection cage made of 6 mm titanium rods with a diameter of 120 mm and a length of 220 mm is delivered with the standard version. The protection cage protects the sensors on the water-floor against shocks and ground contact and guarantees a fine water-flow through the sensors. The protection cage is fastened with a single screw at the lower end of the pressure pipe. As option any other size can be supplied. The version with integrated current meter is supplied with a big size protection cage of 780mm length and 220 mm diameter covering the complete probe.

2.5 CTD90 dimensions and weights

Standard CTD90

- pressure tube length 340 mm
- tube diameter 89 mm
- protection cage diameter 120 mm
- protection cage length 220 mm
- gross length 630 mm
- gross weight 3,5 kg

2000 m version:

- tube 89 * 5,5 mm titanium
- total weight 4,4 kg

6000m version:

- tube 89+7,62 mm titanium
- total weight 5,5kg

CTD90 with current meter (2000 m)

- protection cage diameter 220 mm
- Protection cage height 780 mm
- gross weight (probe) 5,7 kg
- gross length (probe) 700 mm
- weight with protection cage 7,1kg

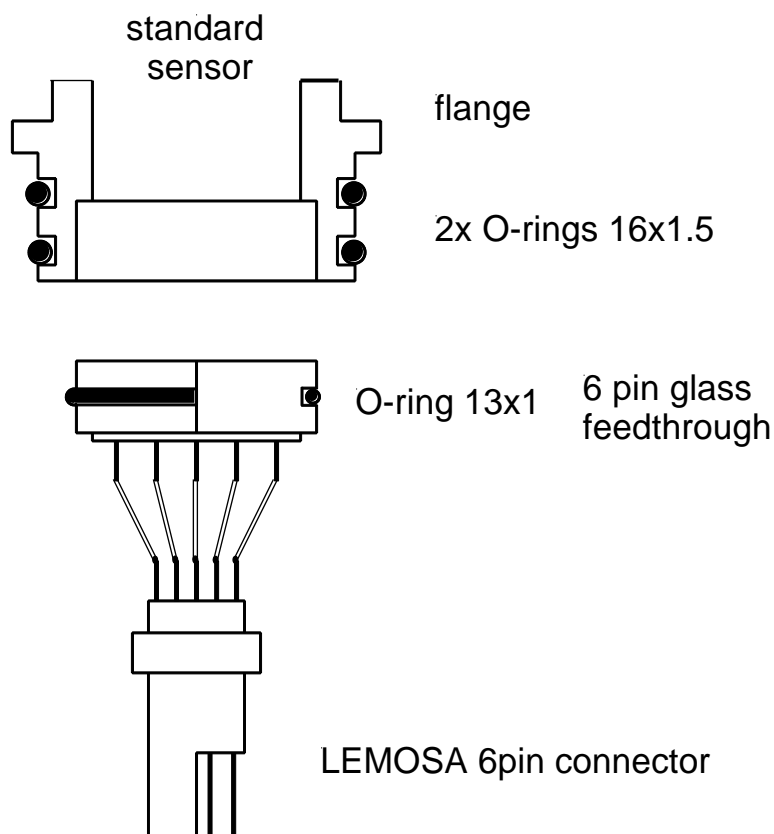
3 Sensors

The CTD 90 has a maximum of 16 analogue channels and 8 digital inputs or outputs for the connection of different sensors. A maximum of 9 sensors fit onto the bottom. The other sensors or instruments have to be connected externally via additional underwater plugs in the sensor lid.

The following sensors can be accommodated in the sensor-base (bottom mounted sensors without cable connection)

- 3.1 Pressure transducer
- 3.2 Ground runner
- 3.3 Temperature sensor Pt 100
- 3.4 Conductivity cell
- 3.5 Oxygen sensor
- 3.6 Ph and redox sensor
- 3.7 Seapoint turbidity meter

The standard sensors have the same flange with an integrated six-pin glass feed through (400 bar) equipped with a small six-pin round connector (see figure below). All of these sensors can therefore be removed from the outside and can easily be replaced without having to open the probe.



External sensors

with analogue outputs and cable connection to the top cap of the CTD90

fluorometer (Seapoint, TRIOS, Cyclops7)

current meter (hs engineers)

transmissiometer

light sensors (LI-COR)

multi water samplers (Hydro-Bios)

multi plankton nets (Hydro-Bios)

fast oxygen sensor (AMT), also available with standard flange

H₂S sensor (AMT), also available with standard flange

methane sensor (CAPSUM)

can be attached and operated as external sensors. Power for external sensors has to be supplied by the CTD90. Standard supply voltage is 12 volt; supply up to 26 VDC is possible.

3.1 Pressure transducer

A piezo-resistive full bridge in OEM version with a diameter of 15 mm and a total height of 6 mm is used as pressure transducer (produced by the Swiss manufacturer KELLER). The casing and diaphragm are made of alloy C276. The transducer is delivered with a small SMD-PCB and includes a temperature compensation of the pressure measurement. The sensor is mounted in the base of the probe; the SMD-board has contacts and is plugged onto the main board of the probe.

Pressure transducer



Technical characteristics

-	Manufacturer	KELLER, Switzerland
-	Model	PA7-XXX Progress (XXX:= full scale range in bar)
-	Dimensions	15 mm diameter, 5,6 mm height
-	Full scale range	1, 2, 5, 10, 20, 50, 100, 200 bar
-	Bursting pressure	150 % of FS range
-	Repeatability	0,1 % of FS range
-	Hysteresis	0,1 % of FS range
-	Zero drift	0,01 %/°C
-	Precision	reduced to 0,1%FS by Progress 0,1 % in the range of -5°...35°C.

3.2 Ground runner

The function of the ground runner is to recognize the sea floor in time during profiling. It helps avoiding damage to the sensors through ground contact. The ground runner mainly consists of a mobile magnet and a reed contact, which are held together by spring tension. During a profile the magnet is pressed against the spring tension by a control weight on a line and so kept away from the reed contact, the contact is open. If the control weight has floor contact the spring release the tension and presses the magnet to the reed contact which is then closed by the magnetic field.

The reed contact produces a digital signal, which is interrogated by the micro-controller and serially, transmitted to the PC.

3.3 Temperature sensor

The temperature sensor is a platinum resistor Pt100 in a tiny ceramic carrier of 15 mm length and 0,9 mm diameter. It is fitted in a slender titanium tube 1,2 * 0,1 mm, about 30 mm long. This delicate tip is resistant to a pressure of 600 bar but it is extremely sensitive to knocks and inflection. Therefore the tip is surrounded by a titanium perforated shield tube, which is mounted onto the standard flange. The platinum resistor is connected in 4-wire technique.



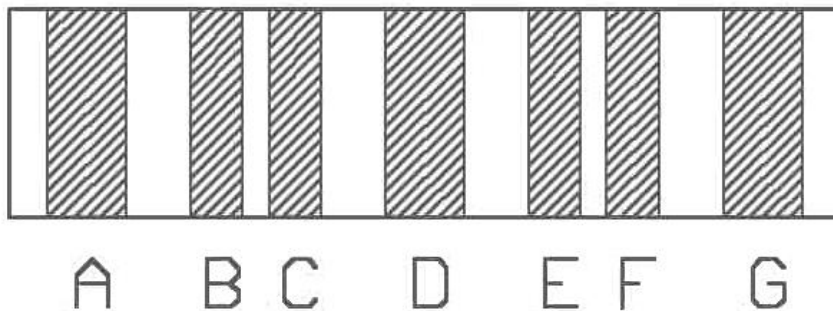
Technical data

Manufacturer	SST
Type	Merz Pt 100/1509
Measuring range	-2°C – 35°C
Response time	approx. 150 msec.
Repeatability	< 0,001°C
Accuracy	0.005°C
Maximum depth	6000 m

3.4 Conductivity cell

Short description of measuring principle

All models of conductivity sensors use 7 electrodes in a cylindrical arrangement. The cell is always constructed symmetrically as depicted in the following sectional drawing.



The central electrode D is used to impress alternating current of 500 Hz to 1 kHz frequency (square wave) into the water volume while both outside electrodes A and G are the current return leads, which are held on a constant potential. There exist two pairs of sensing electrodes (B, C and E, F), which measure the voltage drop across them. The electrical field in a homogeneous medium is symmetrically divided on both half-cells. The constant potential on the outer electrodes limits the electrical field to the inside of the cylinder and prevents any influence from boundary conditions outside the cell. The conductivity electronic is mainly an automatic closed AC control loop which hold the voltage drop across the sensing electrodes on a constant level, while the current is proportional to the actual conductivity value.

Conductivity sensor for profiling

The conductivity cell consists of a quartz glass cylinder with 7 platinum coated electrodes. Because of the small inner diameter of 8 mm the cell needs a minimum vertical flow velocity to obtain full accuracy. The cell is vulcanised with rubber in a mould. The cleaning procedure must be carried out very carefully hence the glass cylinder is sensitive against shock and impact.

Technical characteristics:

Manufacturer	ADM
Model	7-pole electrode cell
Cell factor	K= 1,2
Ranges	0 – 6 mS/cm – 65ms/cm
Response time	100 msec at 0,5 m/sec flow
Reproducibility	< 2µS/cm
Accuracy	20 µS/cm
Maximum depth	1000 m
Min. flow through the cell	10 cm/sec

Conductivity sensor (6000 m)



3.5. Oxygen sensor

The oxygen sensor measures the dissolved oxygen in the water using polarographic methods. The platinum cathode has a diameter of 4mm and is encased with a teflon membrane. The oxygen current consumption ranges from 0 to 12 μA due to the big diameter of the platinum wire. The relative high current consumption requires a minimum current flow of 10 cm/sec in order to avoid oxygen depletion in front of the membrane.

Technical data:

Manufacturer	SST/Oxyguard DO522M18
Type	Clark electrode, self galvanizing
Polarisation voltage:	-0,7 VDC
Range	0 – 200 %
Oxygen current	0 – 30 μA
Temperature range	-2°C – 30°C
Response time	approx. 10 sec (98%)
Accuracy	+ /-3%
Maximum depth	2000 m

Oxygen sensor without protection cap



Oxygen sensor with protection cap

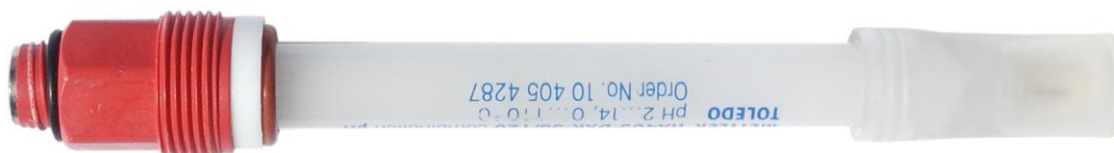


3.6. pH and Redox sensors

3.6.1 Depth range 0..160m

pH and redox combined electrodes are industrial sensors using a solid reference system (stiff polymer mass containing KCl) and an aperture diaphragm which allows direct contact between reference electrolyte and sample medium. Regeneration of the glass membrane or filling up electrolyte is not possible. When the lifetime of the sensor is over, it has to be replaced by a new one. The sensor has a thread PG 13,5 and is screwed into a flange. A coaxial socket makes the electrical contact in the flange. Sealing between sensor and flange is achieved by an O-ring, which is part of the sensor.

Technical data:	pH	Redox
Manufacturer	METTLER-TOLEDO	METTLER-TOLEDO
Model	405-DXK-S8/120	Pt 4805-DXK-S8/120
Measuring range	4-10	-2000mV – 2000 mV
Maximum depth	160m	160 m
Shaft diameter	12 mm	12 mm
Length with flange	167 mm	167 mm
Response time	approx. 1 sec	approx. 1 sec.



3.6.2. Depth range 0..500 m

pH and redox combined electrodes based on the same principles as described in §3.6.1 but more pressure resistant.

Technical data:	pH	Redox
Manufacturer	Hamilton	Hamilton
Model	Polylite PRO 120 XP	Polylite RX 120 XP
Maximum depth	500m	500m

Other technical data same as above (see picture next page).

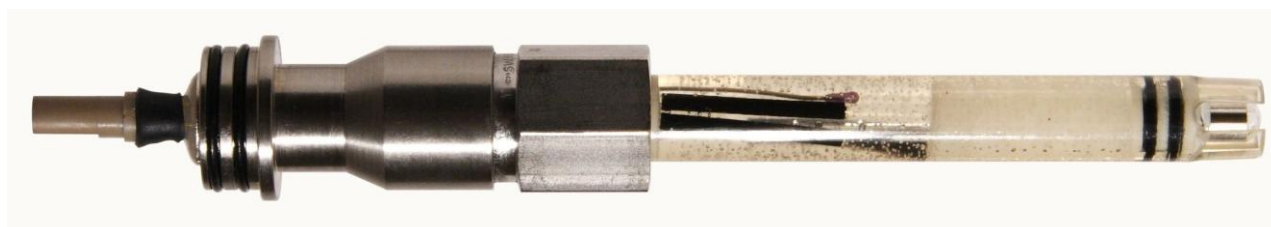


3.6.3. Depth range 1200m

This pH/ORP Sensor uses a pressure-balanced glass electrode with a reference to provide in-situ measurements up to 1200m depth. The sensor is equipped with a reference system using a solid gel (stiff polymer mass containing Ag^+ -free KCl) and a ceramic pore diaphragm and with a pressure stable pH-sensitive glassy electrode. The pH probe is permanently sealed and supplied with a soaker bottle attachment. The bottle contents must be 3 mKCl solution (pH 4) that prevents the reference electrode from drying out during storage.

This sensor is absolutely **H₂S resistant**.

	PH	Redox
Manufacturer	AMT GmbH	AMT GmbH
Measuring range	4-10	-2000mV.. – 2000 mV
Maximum depth*	1200m	1200 m
Shaft diameter	12 mm	12 mm
Shaft material	transparent plastic	transparent plastic
Bulkhead material	Stainless steel	stainless steel
Thread	G1/4 (ISO228)	G1/4 (ISO228)
Shaft length	84mm	84mm
Length with flange	117 mm	117 mm
Response time	approx. 1 sec	approx. 1 sec.



- * This sensor is pressure resistant up to several thousand meters depth with a slight increase of pH/ORP values.

3.7. Seapoint turbidity sensor

The bottom mounted turbidity sensor is based on the SEAPOINT turbidity meter in the bulkhead version, which is screwed onto a standard flange. Electrical connection is achieved by a separable 6 pin round connector. For further details please refer to SEAPOINT's manual.

The Turbidity sensor measures the concentration of suspended matter. It is equipped with a pulsed infrared light transmitter and detects the scattered light from the particles suspended in water. Transmitter and detector arrangement uses 90° scattering at a wavelength of 880 nm. The output signal is proportional to the particle concentration in a very wide range. For detailed description of Seapoint turbidity meter refer to the special user manual.

Specifications:

Power: 7 – 20 VDC, 3,5 mA average
Signal: 0...5 VDC (each range)
Scatterance angle: 90° avg. (15...150°)
Light source wavelength: 880 nm
Linearity: 2%
Depth capability: 6000 m
Size: 2,5 cm diameter, 11 cm length
Ranges: 0-25, 0-125, 0-500, 0-2500 FTU



Picture shows the bulkhead version with flange

The turbidity sensor is available in two different versions: **standard** version has an underwater plug, is connected to the probe via a 6-wire cable and has to be fixed to the probes protection cage with a clamp. The **Bulkhead** version is plugged into a fit of the bottom cap of the probe and hence needs no underwater connection cable. The range can be selected by hardwiring according to the customers requirements.

3.8. Cyclops7 Fluorometer

There is one version of CTD90, that allows the adaption of Turner's cyclops7 fluorometer into the bottom cap of the probe. The cyclops7 is integrated without any modification of the fluorometer housing. To avoid corrosion problems the cyclops7 housing must be made of titanium. The gain setting lines are fixed to a gain of 10 which corresponds to a range of approximately 0-50µg/l. Internal wiring is depicted in drawing 015 M08 04A (see appendix). Modification and change of gain setting requires opening of the CTD90 housing.



For details and hints for application please refer to turner's user manual.

3.9. Multirange sensors

There are a number of sensors, which have several measuring ranges with different sensitivities on a single analogue output. The CTD90 supports these multirange sensors by automatic range switching and transmits measurement values and range information to the board unit in a single 16 bit word. Analogue values have 16-bit resolution. The range code consists of 2 bits and occupies the two least significant bit of the 16 bit measuring value. This limits the real resolution of the multirange sensors to 14 bits. But since all these sensors doesn't need CTD resolution the overall accuracy is not affected by this procedure.

3.9.1. Seapoint turbidity meter

Description is given in §3.7. Beside the hardwiring of the selected range the CTD90 offers the possibility of automatic range switching.

Both versions have 4 ranges, which are controlled by two independent gain control lines A and B:

range	B	A	gain	calibration range
0	0	0	*1	0...2500 FTU (linear up to 1000 FTU)
1	1	0	*5	0.....500 FTU
2	0	1	*20	0 125 FTU
3	1	1	*100	0 25 FTU

0:= line tied to GND

1:= line left open

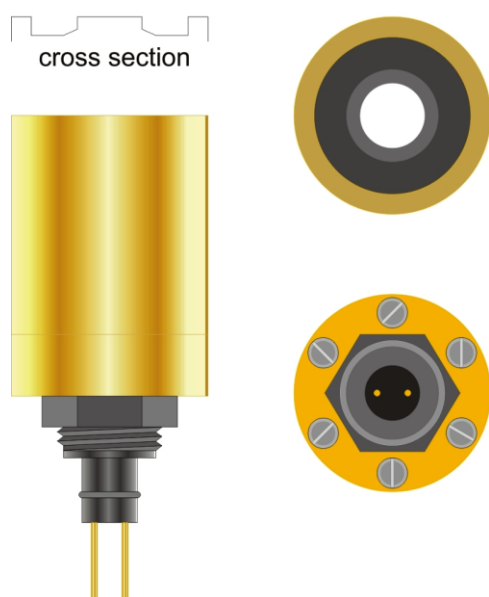
The CTD electronic monitors the signal output of the turbidity sensor and selects automatically the next suitable range if a certain limit is exceeded or dropped. The limits are approximately 10% resp. 90% of the current range. The instrument is factory calibrated with a formazine turbidity standard.

3.9.2. LI-COR Quantum sensor

is used for measuring **Photo synthetically Active Radiation (PAR)** in aquatic environments. Due to its 400 – 700 nm quantum response it is a suitable sensor for investigation of the primary production. LICOR offers two different underwater sensors:

LI-192SA cosine corrected quantum sensor (following Lambert's cosine law) measures the **Photosynthetic Photon Flux Density (PPFD)** through a plane surface (photon or quantum irradiance between 400 and 700 nm)

Li-Cor sensor
type 192 SA
UWQ no 6478



LI-193SA spherical quantum sensor determines specifically the **Photosynthetic Photon Flux Fluence Rate (PPFFR)**, the number of photons in the visible range incident per unit time on the surface of a sphere divided by its cross sectional area.



Both instruments are calibrated in $\mu\text{mol/s}\cdot\text{m}^2$ (μE) where 1 μmol is $6,023 \cdot 10^{17}$ photons.

Specification:

Detector: silicon photodiode

Range: 0 ... 10000 $\mu\text{mol/s}\cdot\text{m}^2$

Calibration accuracy: 5%

Linearity: 1%

Long term stability: 2% per year

depth capability: 350 m (LI-193SA) / 550 m (LI-192SA)

Sensitivity: typical 3 μA / 1000 μE

Both sensors will be connected to the probe by a 2 wire underwater cable. Please note: the light sensors must be mounted on the top of the probe to avoid shade of neighboured instruments.

The dynamic measuring range (sensitivity of the photodiode) covers approximately 7 to 8 decades of light intensity. Logarithmic amplifiers have a different resolution depending on the current value. To avoid this disadvantage the complete range is divided into 4 decades each with 14-bit resolution.

range	range code		current [μ A]	PPFFR / PPFD (*)
0	0	0	0.....0,05	0.....12
1	1	0	0 0,5	0.....125
2	0	1	0.....5	0...1250
3	1	1	0 50	0..12500

(*) calculated for LI-multiplier of 250

The result is a linear response from 0,001 up to 10000 μ mol/s*m².

Range switching is executed automatically when the measuring value increases the 95% full scale level or decreases 5% FS of the current range.

3.9.3. Seapoint Fluorometer



measures chlorophyll A concentration in 4 different ranges, which are selected by two control lines A and B

range	range code (B/A)		Concentration [$\mu\text{g/L}$]
0	0	0	0...150
1	1	0	0 50
2	0	1	0 15
3	1	1	0.....5

The range switching procedure is similar to the turbidity meter; the limits are 90% and 10% of full scale.

The instrument has a six pin underwater plug (Impulse AG306) and has to be connected by a cable to the CTD.

Specifications:

Power: 8 – 20 VDC, 15 mA average

Signal: 0 – 5 VDC (each range)

Light source: blue LED 470 nm

Detector: photodiode 680 nm

Min. detection level: 0,02 $\mu\text{g/l}$

Depth capability: 6000 m

Size: 64 mm diameter, 168 mm length

The instrument is also available in a version to measure DOC (dissolved organic matter or yellow substances).

4 Replacement of sensors, opening the probe

When replacing a sensor the probe generally doesn't have to be opened (exception: pressure sensor). Proceed as follows:

- remove both of the M4-screws which hold the flange
- carefully remove the respective sensor whilst gently turning it out of its fitting in the base
- disconnect the plug contacts (pull lightly).

Reassemble in opposite order. To remove the pressure sensor the probe has to be opened. This is done in the following order:

- remove the protection case
- take the lid off: first of all unscrew the 4M3-screws on the side of the tube-end and then pull the lid off whilst gently turning it without tilting it detach the base from the tube (as with the lid)
- disconnect all of the sensor plugs, unsolder the pressure sensor cable on the main board
- detach the bedplate from the base, unscrew the pressure sensor holding screw
- pull the sensor out carefully by its cable (from 100 m range upwards blow it out, if necessary, with compressed air from the front side)

Attention: When replacing the pressure sensor the progress-print must always be replaced as well because it contains the temperature compensation for the specific pressure sensor. When inserting the new pressure sensor grease the O-ring thoroughly. Reassembling is done in the opposite sequence.

5 Probe electronics

The electronics of the basic version consists of two printed circuit boards

1. Power supply and cable driver
2. Main board and plug-in modules.
3. Expansion board

5.1 Probe power supply

is situated on a small circular board (50 mm diameter), which is screwed to the inside of the lid. This board contains the DC-DC-converter for the probes operating voltages (5 volt and –5 volt), the FSK modulator, the cable driver and the zenerdiode for constant current supply. Components, which produce a considerable heat, are screwed onto the lid, thus using the good thermal contact for heat abduction to the metal housing and seawater (cable driver transistor, zenerdiode). The wires of the probes underwater connector are soldered onto this board; the connection to the main board is separable by a plug.

5.2 The main board

Measures 250 mm * 50 mm and contains the following circuitry:

- Data acquisition module as SMD plug-in board
- 8 channel analogue multiplexer
- RS-232 driver
- Water sampler releaser
- Temperature bridge
- Conductivity control circuit
- Pressure amplifier (with Progress-print as plug-in module)
- Oxygen amplifier
- Redox amplifier
- PH amplifier
- Differential amplifier for sensors with analogue output

The main board has an expansion plug which contains all necessary signals for a system extension to 16 sensors. On the backside of the bedplate a further same sized additional printed circuit board can be attached which incorporates the electronics for further sensors.

ADC Module

The heart of the probe is a microprocessor controlled 20-bit analogue digital converter, which generates an auto calibration cycle each time the probe is switched on. This results in an exceptionally good long-term stability. This is especially important for the stability and precision of the CTD sensors.

5.3. Expansion board

The expansion board is equipped with a second 8-channel analogue multiplexer for the upper address range from 8 to 15. This board provides the plug in position for all multirange sensor electronics and the interface circuitry for current meter and compass.

6 Power supply, connector pin assignment and interfaces

The CTD90 has a 4-pin underwater connector, which allows the probe to be operated in different modes. The standard connector is SUBCONN MCBH4M made of titanium. For compatibility to existing systems a SUBCONN BH4M can also be used.

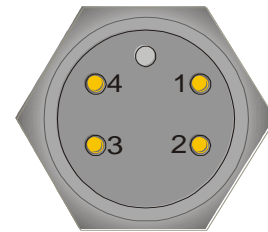
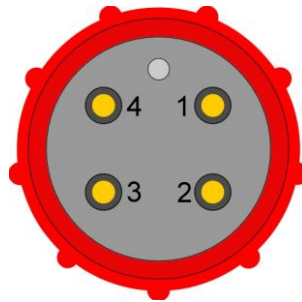
Pin assignment:

BH4M

MCBH4M

Bulkhead connector

Pin1 $+I_k$ / FSK signal
 Pin2 TxD (RS232)
 Pin3 $-I_k$ / $-U_b$ / GND
 Pin4 $+ U_b$

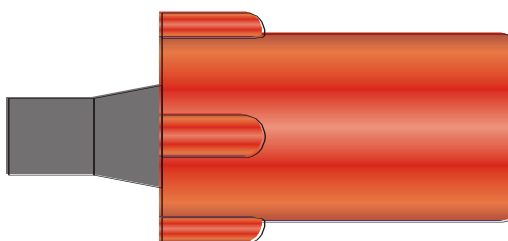


6.1 Operation with multicore cables

The use of multicore cables is advisable for shorter distances between probe and PC and particularly in a laboratory. The probe is then supplied either by a battery or a regulated power supply. The voltage is applied to Pin3 (negative) and Pin4 (positive). Data transfer to the PC is via pin2 (Transmit data TxD) and pin3 (GND). The wiring of such a cable is described below.

Inline cable IL4F	signal	9-pin SUB-D plug DB25S
Pin 2	TxD	Pin 3
Pin 3	GND	Pin 5
Pin 3	- U_b	banana plug black
Pin 4	+ U_b	banana plug red

MCIL4F with locking sleeve



The supply voltage ranges from 9 to 26 volt DC. The probe is designed for connection to 12-volt batteries or to regulated power supply. The current consumption is about 50 mA for a C,T,D,O₂,pH,ORP.

The maximum supply voltage is 26 volt. Higher voltages cause destruction of components. Damage due to overvoltage is not covered by the guarantee. Connection to unregulated power supplies, in particular motor-driven emergency power supplies, is not advisable.

The maximum length of the multicore cables depends mainly on the cable resistance and can at best be several hundred meters. An advantage is that a specific interface between probe and PC is not necessary.

6.2 Operation with single conductor cables

The standard application of CTD-probes is profiling performed via winches with slip rings and single conductor cables. Constant current then supplies the CTD90; the FSK signal is impressed on the constant current as voltage modulation. An interface between PC and winch (probe) produces the constant current and converts the FSK-signal from the probe into PC-compatible V24 data. The maximum voltage of the current source depends on the cable resistance (cable length). The wiring is as follows:

Inline cable	Signal	cable
Pin 1	+ I _k /FSK-signal	internal wire
Pin 3	-I _k	shield

The basic version has a constant current of about 60 mA; this can be distinctly higher when external devices are connected. The voltage drop between Pin 1 and Pin 3 is approximately 17-18 volt. The FSK signal is a sinusoidal signal of approx. 5V_{ss} and modulated on the constant level. A logical LOW-level is the equivalent to the low frequency; a HIGH-level is equivalent to the higher frequency. The frequencies are 35kHz and 45 kHz.

The TxD signal on pin 2 of the probe connector is identical with the RS-232 output of the probe interface.

7 Service and maintenance

The best maintenance for the probe is to handle it with care. Despite the fact that the probe is sturdily and stabile designed, unnecessary strains like knocking and shocks should be avoided. Apart from that, there are only few instructions and maintenance rules, which should be heeded or met to, so as to ensure a longer life span and correct measuring, results.

7.1 The underwater connector

Is actually maintenance-free. However it has proved itself to be advisable to lubricate the sealing surfaces of the pins with sea waterproof grease. This reduces wear whilst plugging and unplugging. Further tips:

- clean the plugs with warm soapy water. They do not have to be dried. Chemicals should be avoided.
- To avoid corrosion never plug or unplug whilst under water
- To conserve the cable plug never unplug by pulling on the cable. Avoid bending radiuses and above all narrow, sharp kins.
- Plugs that are not in use should never be left blank. They should always be protected against corrosion by a dummy cap.

7.2 Pressure sensor

The pressure sensor doesn't require special attendance or maintenance. Personnel experience has shown however, that the pressure sensors should never be tested by pressing a pin onto the membrane. This often causes damage to the membrane or dents it, which can lead to pressure reading mistakes or to a total damage. Pressure sensors damaged in such a way are not covered by the guarantee.

7.3 The temperature sensor

The temperature sensor is maintenance free. Dirt and plant cover only prolong the time constant but have no effect on the precision. When cleaning the sensor take special care of the sensitive tip, which should not be bent.

7.4. The conductivity cell

Is principally not maintenance free. It must regularly be inspected for plant cover and electrolytic calcification. Both effects reduce the measured conductivity. It is appropriate if the probe is rinsed on deck with fresh water after each application. This prevents the formation of salt crystals on the cell surface. Calcareous deposits, which originate from the electrical current flow in the cell, are easily removed if the cell is immersed for a few minutes in a diluted acid. The quantity of rising CO₂-bubbles gives information on the rate of calcification. The cell is completely decalcified when the bubble formation has ceased. Afterwards the cell has to be rinsed with fresh water. Depending on the operating time this procedure is only necessary every few months. Cleaning is more difficult after long-time application especially during warm months, when heavy sea-pest growth densely populates the cell within a short time (2 weeks). In this case the cell has to be placed into diluted acid (if necessary for a longer time) and then a plastic bottlebrush has to be pushed through it. This procedure may have to be repeated until the cell is completely cleaned. Then the cell is rinsed with fresh water. Particular care has to be taken, that the metal components on the electrode surfaces are not scratched, nor must they come into contact with other metals. Otherwise the lifetime of the cell and the long-time stability of the conductivity measurements will be impaired. After the electrodes have been treated with acid a short-term increased conductivity reading may occur, this should normalize itself within an hour.

7.5. Oxygen sensor

The oxygen sensor requires some attention from time to time. All the necessary maintenance like exchange of electrolyte and membrane is described in an OxyGuard leaflet in the appendix of this manual.

The red O-ring has two different positions:

1. in the **front position** (shown in the picture below) the O-ring prevents leakage of the electrolyte through the thread during storage. **This position should not be used for measurements but only for storage.**



2. in the **backward position** it allows the electrolyte to build a high impedance electrolytic connection between medium (sea water) and electrolyte room behind the membrane. This connection is **necessary for proper measurements. Please take care that during measurements the O-ring takes always the backward position**



The Oxyguard DO sensor is supplied by us with a sensor protection cap made of plastic . To achieve a tight fit to the sensor head the cap is equipped with an O-ring 21*1 mm and a 2mm hole in the center of the bottom (see photo). The cap should be used as protection for the membrane and sensor head as well as useful tool for oxygen field calibration.



If the membrane tension is dropping during operation or time the sensors output signal is changing too. The zero point of the oxygen sensor remains fix during its lifetime but the sensivity (slope) can vary. The user can execute a field calibration after each membrane exchange or when he doesn't trust the measured values anymore.

Field calibration

The SDA software offers the possibility to perform a field calibration and to change the reading automatically. Let the SDA program run with the probe connected to the PC. The field calibration procedure is very simple:

- Keep the membrane of the DO sensor dry
- Put the red o-ring in the backward position
- plug the protection cap onto the sensor head with a proper fitting o-ring
- Fill a small plastic cup with water and immerse the sensor head up to the flange (small white plastic cup is part of the delivery)
- after a short time the enclosed air in the cap is water vapour saturated and the the oxygen reading should have 100% partial pressure.
- If the oxygen reading is stable click menu point **Calibrate** and **02 Field Calib**
- When **02 Field Calib** is selected, the current oxygen reading is automatically stored. The default value **100%** is accepted when clicking on the button **Calculate slope now**.
- The SDA programm calculates the new oxygen Field calibration coefficient (originally 1) and the reading is now 100%.

The field calibration method works in any basin or tank and the result is independent of the salinity. When putting the complete probe into a basin you have to estimate the immersion depth of the oxygen sensor (measured from the membrane to water surface). Every 10 cm immersion depth lead to an increase of the oxygen reading of 1%. So e.g. if the procedure is executed with the DO sensor 30cm below the water surface, the default value in the button field **Enter desired value** has to be changed to 103%.

7.6. pH and Redox sensor (160m + 500m)

Both sensors are principally maintenance free. After its life span has ended the corresponding sensor has to be replaced. When unscrewing the sensors no moisture (e.g. water drops) what so ever must reach the contacts (dry beforehand). A single drop of saltwater is enough to cause long-lasting incorrect measurements – this is due to the high output impedance of 100 – 400 MΩ. So only replace sensors under clean and dry conditions please.

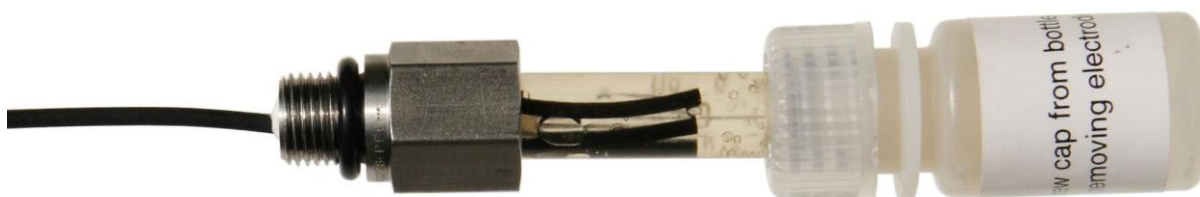
The life span of the sensors ceases when the time constant of the pH or redox measurement drastically increases. The life span has also ended when the reference electrolyte is dissolved down to the screw thread rim. Water can then possibly leak in through the bolting. The pH and Redox sensors are particularly endangered when they come into contact with H₂S in water.

Some minutes in hydrogen sulphide is enough to irreparably ruin the sensor. In most cases stable-measuring results cannot be achieved anymore despite lengthy rinses with cleansing or buffer solutions. If measurements in H_2S -concentrations are necessary we recommend to remove the sensors and to screw on locking caps (or to use the 1200m sensor; refer to 7.7.)

Special care has to be taken that before using the sensor no air bubble is to be found in the pH electrolyte directly behind the ion-permeable glass layer because it would interrupt the internal electrical connection to the pH electrode. The air bubble has to be shaken out – similar to the shaking of a thermometer. The air-bubble often occurs when the sensor has been stored horizontally for a longer time.

7.7 pH/ORP sensor (1200m, H_2S resistant)

Do never touch the sensitive tip. Protect the pH-sensor with the delivered soaker bottle containing the storage solution and avoid any dry out of the sensitive tip.



Avoid any air inside the bottle, fill completely with 3 M KCl. Make sure, that only 3 M KCl with pH 4 buffer is used for storage. It is not allowed to use other wetting caps in order to avoid any air pressing into the diaphragm leading to sensor malfunctions or damage. Damage because of using other wetting caps or storage without any wetting cap is not covered by guarantee. The pH sensor has to be rinsed carefully with fresh water after finishing the measurements.

The pH sensor is a replacement part and has to be changed, if the sensor has reached the lifetime. The sensor has a stainless steel thread G1/4A (titanium on request) which is screwed into a flange. The electrical contact is made by a socket in the flange. Sealing between sensor and flange is achieved by an O-ring which is part of the sensor. After the sensor's life span has ended, the sensor has to be replaced.

7.8. Seapoint turbidity meter

The turbidity sensor has to be cleaned from time to time. Especially the optical sensitive flat surfaces have always to be kept clean. Avoid the use of chemical solvents. Make use of the protection cap if the sensor is not in operation.

8. Probe data format

The probe data can be fed into the PC serial ports COM1 to COM4. The standard settings of the probe are:

Baud rate	1200 (2400, 4800, 9600)
Character length	8
Number of stop bits	1
Parity	odd
Protocol	non, asynchronous
Signals	GND, TxD

The data is transmitted as binary data. 3 bytes (24 bit) per sensor are required, 16 bits are measuring values, 5 bits are address and 3 are status bits. The transmission format is presented in the following chart:

Sensor	LSB							MSB
1. Byte	H	D0	D1	D2	D3	D4	D5	D6
2. Byte	H	D7	D8	D9	D10	D11	D12	D13
3. Byte	L	D14	D15	A0	A1	A2	A3	A4

DO – D15	16 bit binary data (decimal value 0 – 65535)
AO – A4	5 bit binary address (decimal sensor address 0-31)
H, H, L	3 status bits 1,1,0

A sensor data transmission starts with the 1. Byte (LSB first) and ends with the third byte (MSB last). Every sensor in the probe has a specifically assigned binary address which identifies the kind of sensor. The status bits are useful for the PC data acquisition programmes to compile the 3 bytes in the correct sequence.

A complete data set begins with the lowest address and ends with the highest address. All addresses between 0 and 31 may occur. The transmitted physical addresses are identified by the data acquisition program and compared to those registered in the configuration file. As an example the addresses for the CTD90:

Address 0	light transmission
Address 1	probe serial number, ground runner)
Address 2	pressure
Address 3	temperature
Address 4	conductivity
Address 5	oxygen
Address 6	pH
Address 7	redox

The remaining vacant addresses can be used for external probes or sensors.

Address 1 Housekeeping data

The ground runner is always transmitted on the address 1 as LSB:

D0 = LOW no floor contact
D0 = HIGH floor contact

If the probe number transmission is activated it will be transmitted on the upper 15 bytes of the address 1: D15...D1.

Multirange sensors:

A multirange sensor with databits D15...D0 carries the range information in the least significant two bits D1, D0:

range D0 D1

Range 0 (0, 0)
Range 1 (1, 0)
Range 2 (0, 1)
Range 3 (1, 1)

The true resolution of a multirange sensor is therefore 14 bit , but the sensor data is handled by the SDA program like any other 16 bit value. The range information is used by the SDA software to load the correct calibration coefficients for the calculation of the engineering units.

9 Calculation of the physical data

Data transmission and data storage when online are performed solely in binary dates. The PC-data acquisition program carries out the calculation of the physical values from the raw data and their display. The calculation of physical values for standard sensors is made by a polynomial of n.th order:

$$\text{Measurement value:} = \sum A_i * n^i$$

A_i calibration coefficients

$i = 0...4$

Normally $i_{\max} = 1$ or $i_{\max} = 2$. The coefficients are determined by calibration measurements against a normal or subnormal and subsequent regression calculations.

Further calculations such as the absolute oxygen concentration, salinity, density and sound velocity are carried out with the current UNESCO-formulas.

10. Spare parts

10.1. Sensors

- pH sensor 160m METTLER-TOLEDO HA405-DXK-S8/120
- Redox sensor 160m METTLER-TOLEDO Pt4805-DXK-S8/120
- PH sensor 500m HAMILTON PolyLite PRO 120 XP
- ORP sensor 500m HAMILTON PolyLite RX 120 XP
- PH and ORP 1200m on request
- Pressure sensor KELLER PA7-XXX Progress 0,1 - 2 Volt
(XXX Full scale range in bar)

10.2. O rings

- Base and lid 76 * 2,5 mm
- Sensors (flange) 16 * 1,5 mm
- pressure sensor 13 * 1 mm (stainless Steel 316L)
12 * 1,5 mm (alloy C276)
- PH/Redox sensor 12 * 1,5 mm (160m, 500m)
- Underwater connector 12,42 * 1,78 mm

10.3. Plugs and cables

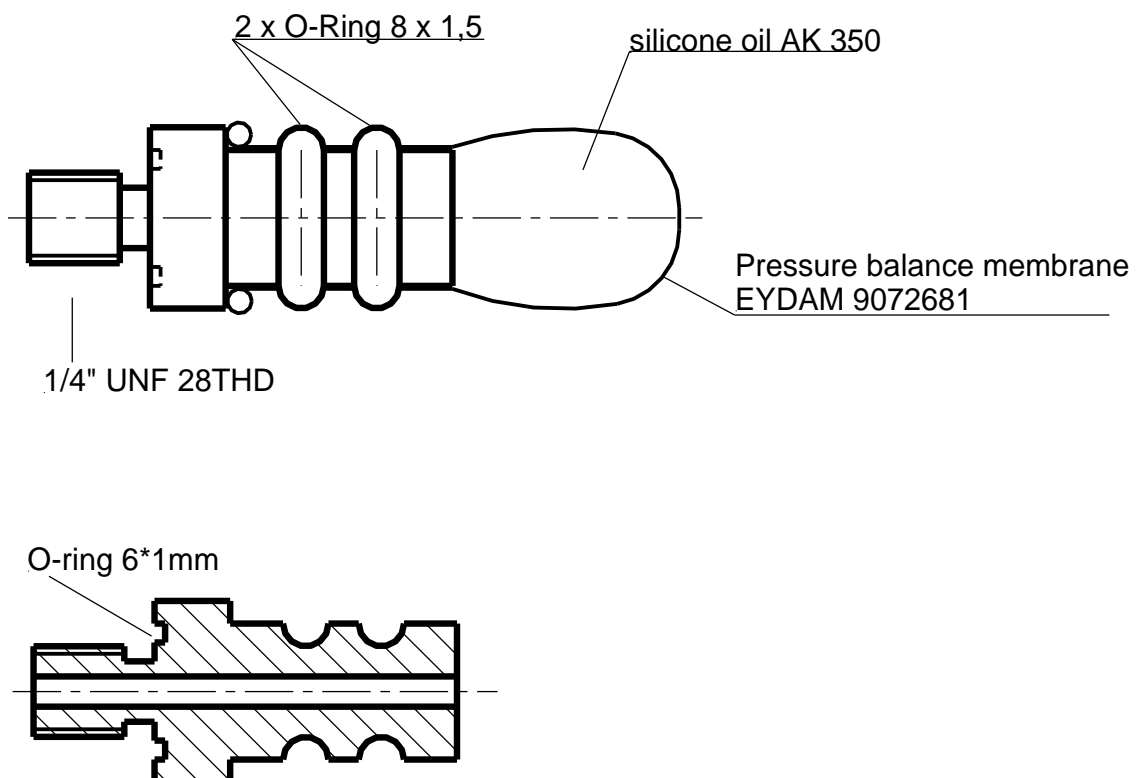
- Dummy cap SUBCONN MCDC4F / DC4F
- Locking sleeve SUBCONN MCDLS-F / DLSA
- Inline connector SUBCONN MCIL4F / IL4F

Appendix

Corrosion protection for pressure transducer

Standard application for CTD 90 is profiling. If the probe is used for long-term measurements like permanent monitoring or mounted stationary on ships, special care should be taken with the pressure transducer. Exposed for a long time to seawater, problems may rise with corrosion of the welded seam between the transducer's diaphragm and housing. Especially low oxygen concentrations increase the danger of corrosion.

To solve the problem and to ensure a long lifetime of the pressure transducer, we recommend to use the small $\frac{1}{4}$ "UNF(M8) adapter, which is depicted below. This plastic adapter is screwed into the calibration connection thread and sealed with an O-ring 6*1 mm, the other end is closed by a pressure balance membrane held by two O-rings 8*1,5 mm. The inside is filled with silicone oil AK350. The performance and accuracy of the pressure measurement is only slightly increased.

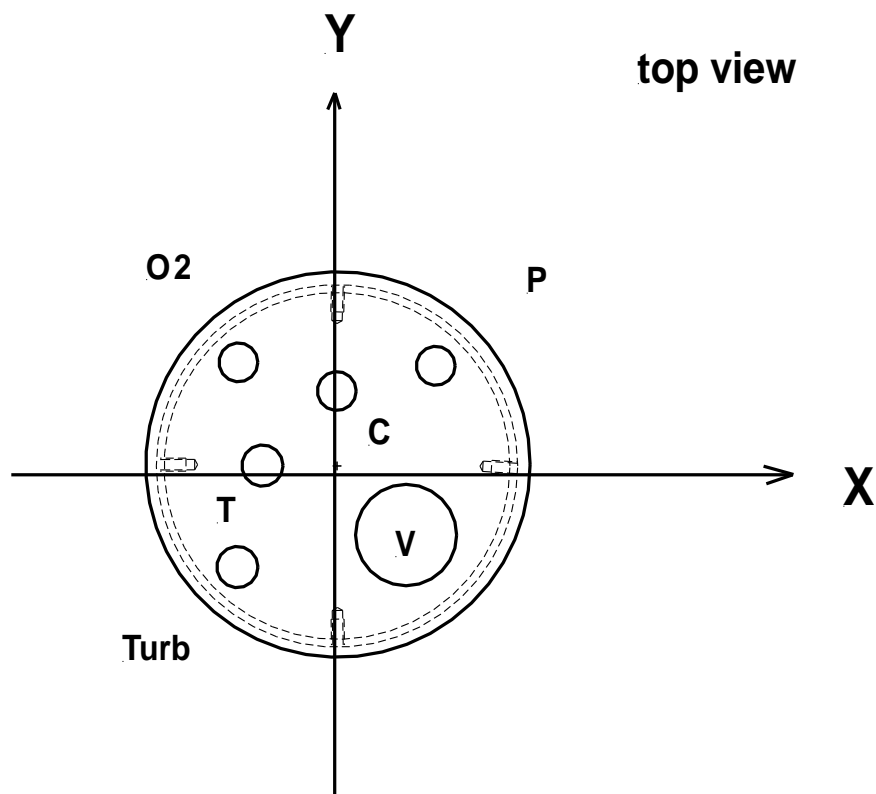


Appendix

CTD90 Sno.20, current meter and compass

Definition of terms

The instrument axes of current meter and compass integrated in the CTD90 are defined by an orthogonal co-ordinate system depicted in the diagram below:

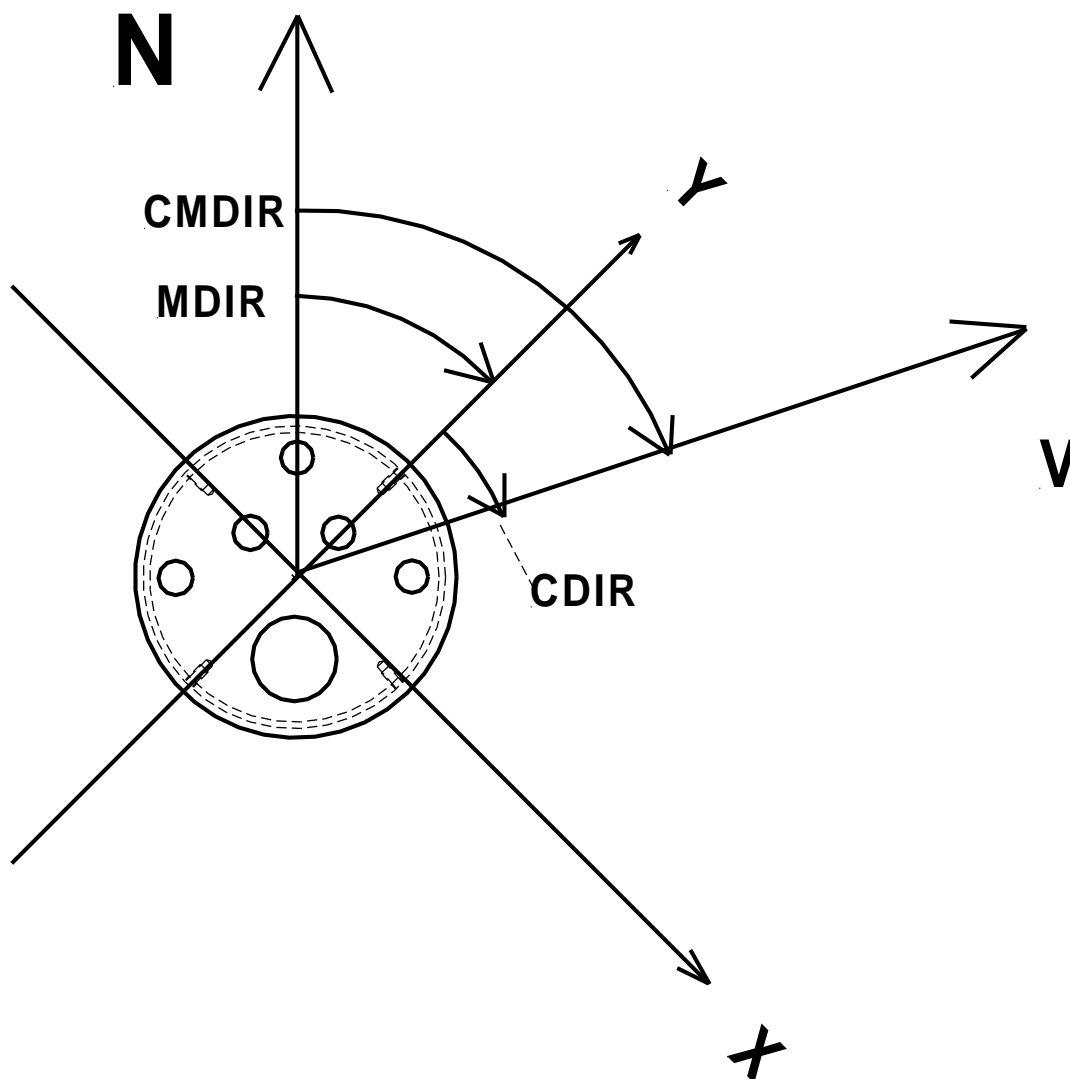


Since the OEM current meter and compass are mounted on the bottom cap of the probe, the arrangement of the fits on the bottom determines the axis directions.

The SDA menu allows the acquisition of the 4 measuring parameters V_x , V_y , H_x , H_y for the current velocity and magnetic field intensities. The user can select between 3 different calculated directions:

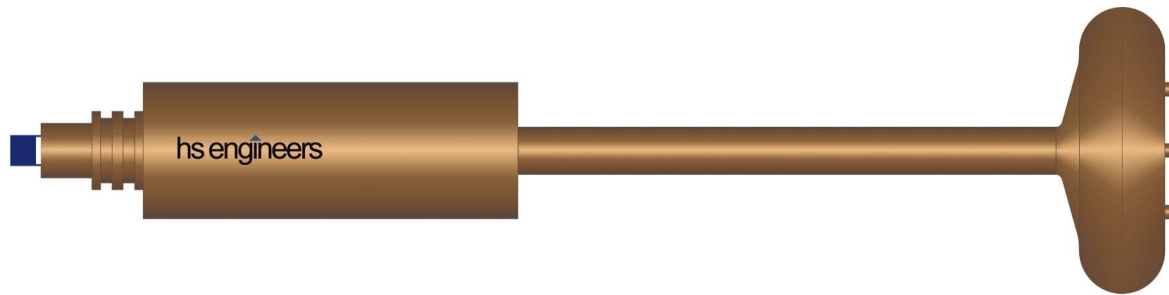
- MDIR
- CDIR
- CMDIR

The angles are counting clockwise against the North direction (see picture below):



MDIR angle between North direction and positive Y-axis
CDIR angle between current vector and positive Y-axis
CMDIR angle between current vector and magnetic north

Picture of the hs engineers inductive current meter type ISM-2001F



Example: CTD90 probe with current meter and deep-sea conductivity sensor

